

**INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH
TECHNOLOGY****STUDY AND VIBRATION ANALYSIS OF MULTIPOINT CUTTING TOOLS OF
MILLING MACHINE BY FEM AND ANSYS BENCHMARK 14.0****Ronak Singh Bhatia^{*1}, Er. Nikhilesh N. Singh² & Dr. Prabhat Kumar Sinha³**^{*1}M.Tech Scholar, Department of Mechanical Engineering, SHUATS, Allahabad, UP. INDIA^{2&3}Assistant Professor, Department of Mechanical Engineering, SHUATS, Allahabad. U.P. INDIA

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ABSTRACT

In the present article, the research has been conducted for high frequency vibration and the total deformation of face milling cutter (micro level) to predict the deformation under varying frequencies developed in high speed machining operations. Under this, the work has been accomplished in tool vibration for predicting tool life and tool wear. This current work highlights the model of face milling cutter with tool inserts for static and dynamic components of cutting process. The computer generation has been created using CATIA V5 to stimulate the deformation process. Many simulation models use finite element analysis to calculate the reaction of cutting tool. The objective here is to consider the design and modeling of face milling cutter with inserts using CATIA V5 and FEA is carried out by using Ansys 14.0 and on comparing the two models, it has been found that cemented carbide is better due to less deformation and high strength.

Keywords: Multi Point Cutting Tool (cemented carbide), Catia v5, Ansys 14.0, Solid Modeling and Finite Element Analysis.

I. INTRODUCTION

In manufacturing, the process of removal of undesirable segments of metal work pieces in the form of chips is known as machining, so as to attain a finished product of the desired size, shape,

and surface quality. The machining cutting process can be branched into two major groups (i) cutting process with traditional machining (e.g., turning, milling, boring and grinding) and (ii) cutting process with modern machining (e.g., Electrical Discharge Machining (EDM) and Abrasive-Jet (AWJ)).

The basic element of the modern metal removal process consists of a machine tool, a control system and the cutting tool. An immense revolution in metal cutting practice takes place as machining is typically carried out using devoted, specially designed machining systems for mass production. A flexible, agile, or reconfigurable machining system based on Computerized Numeric Control machine tools, the development of open architecture computer based controls and progression of new tooling materials have greatly influenced metal cutting practice. Milling is the most frequent metal cutting operations in which the material is removed by advancing work piece against a rotating multiple point cutting tool. Milling is typically used to produce parts that are not axially symmetric and have multiple features, such as holes, slots, pockets, and even three dimensional surface contours. Contoured surfaces, which include rack and circular gears, spheres, helical, ratchets, sprockets, cams, and other shapes, can be readily cut by using milling operation. Recently, micro milling process has gained immense popularity due to market requirements and technological advancements which has lead to fabrication and use of micro structures. It possesses several advantages like ease of use, capability to produce complex three dimensional geometries, process flexibility, low set-up cost, wide range of machinable materials and high material removal rates.

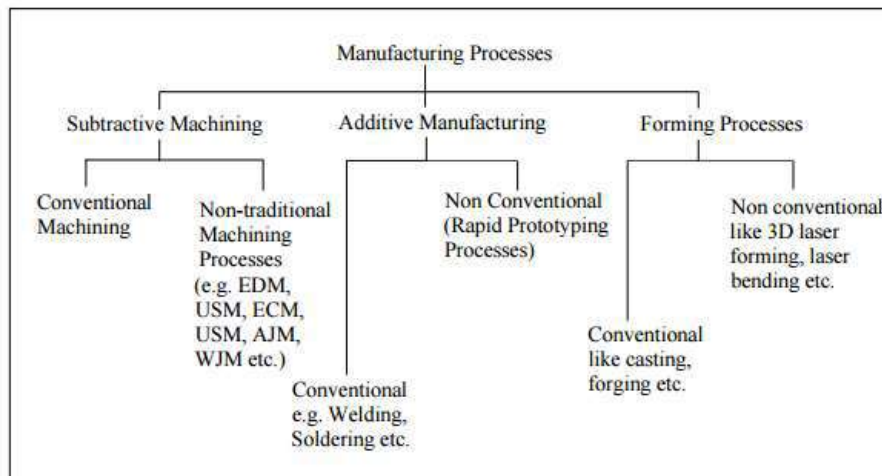


Fig. 1 Classification of Manufacturing Processes

Conventional milling has a wide range of industrial applications and is used where there is a requirement of complex shapes, removal of large amounts of material, and accuracy. However, with the advancement in technology, more and more industries are leaning towards the use and fabrication of miniaturized parts and products. In the present scenario, micromachining is increasingly finding application in various fields like biomedical devices, avionics, medicine, optics, communication, and electronics. Among all micro-machining operations, micro-milling and micro drilling are the two most important operations. In today's competitive world, every industry is dependent on the adequate functionality of its micro components. Automobile and aerospace industries need extremely good quality machined components due to greater complexity of the workpiece, tighter tolerances, miniaturization and use of new composite materials. In case of biomedical devices, there are stringent requirements for form and finish of the product like metallic optics and cochlear implants. Good surface finish of micro-components is needed for proper functioning of the products, and for proper mating of microparts. Protruding edges at the boundary of the machined surface are called burrs. Burr removal is necessary for good surface finish. In case of conventional milling, surface finishing is done by either improving the machining setup or changing the tool geometry. Burr removal can be done by using various deburring processes. However, controlling burr formation in micro milling can be very challenging because of the sub-micrometer size of the burrs produced. Furthermore, in micro-milling operation, deburring solutions utilized in conventional machining are not allowed due to inherent material characteristics or limitations in part geometry. Deburring processes allowed in micro milling are expensive and can lead to micro structural damage. Optimization of various machine parameters, like cutting speed, feed rate and depth of cut, or tool parameters, like rake and relief angle, can help in minimization of micro-burrs in micro milling operations. An accurate surface geometry of micro milling cutters is one of the essential parameters responsible for the control of micro burrs in micro milling. Very limited work has been done on the control and minimization of micro burrs formed during micro milling operation. Virtual finite element analysis of micro burr formation during micro milling process is a cost effective method for obtaining optimized tool parameters for minimum burr formation.

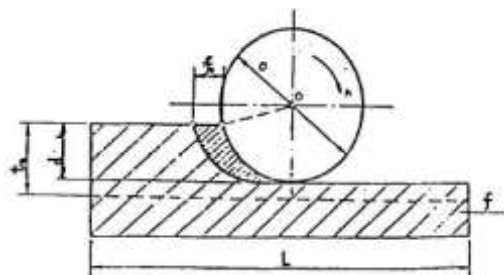


Fig. 2 working motions of plain milling operation

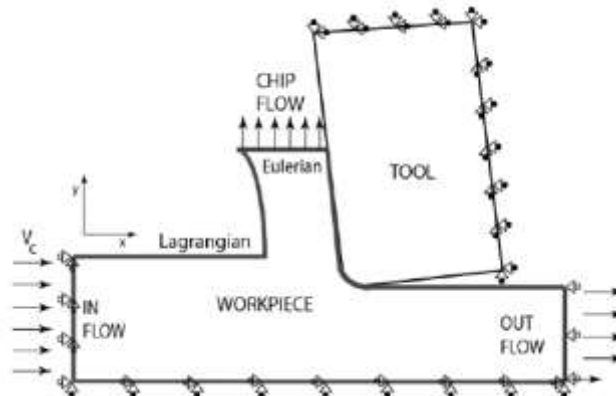


Fig. 3 Eulerian and Lagrangian boundary conditions in ALE simulation

Face mill cutter

A face mill is a cutter designed for facing as opposed to e.g., creating a pocket (end mills). The cutting edges of face mills are always located along its sides. As such it must always cut in a horizontal direction at a given depth coming from outside the stock. Multiple teeth distribute the chip load, and since the teeth are normally disposable carbide inserts, this combination allows for very large and efficient face milling.



Fig. 6 Face mill tipped with carbide inserts

II. FINITE ELEMENT ANALYSIS

Computer-aided engineering (CAE) is the application of computer software in engineering to evaluate components and assemblies. It encompasses simulation, validation, and optimization of products and manufacturing tools. The primary application of CAE, used in civil, mechanical, aerospace, and electronic engineering, takes the form of FEA alongside computer-aided design (CAD).

Finite element analysis

In general, there are three phases in any computer-aided engineering task:

- Pre-processing – defining the finite element model and environmental factors to be applied to it.
- Analysis solver – solution of finite element model
- Post-processing of results using visualization tools.

Proposed Method for Analysis

Various outputs and characteristic of the metal cutting processes such as cutting forces, stresses, temperatures, chip shape, etc. can be predicted by using FEM without doing any experiment.

Lagrangian method Lagrangian formulation is used mainly in problems on solid mechanics. In this, the mesh moves and distorts with the material being modeled as a result of forces from neighboring elements. It is highly preferred when flow of material involved is unconstrained.

Boundaries and chip shape need not be known beforehand. Simulation of discontinuous chips or material fracture can be done by using chip separation criteria in metal cutting models based on Lagrangian formulation. However, metal being suffers severe plastic deformation and distortion occurs. Mesh regeneration is therefore

needed. Chip separation criteria also must be provided. Eulerian method In Eulerian formulation, the FE mesh is fixed spatially, which allows materials to flow from one element to the next. Besides, fewer elements are required for the analysis, which reduces the computation time. However, determination of the boundaries and the chip shape needs to be done prior to the simulation. Also during the analysis, the tool-chip contact length, the contact conditions between tool-chip and the chip thickness, have to be kept constant

Arbitrary Lagrangian-Eulerian (ALE) method Arbitrary Lagrangian-Eulerian (ALE) combines the best features of Eulerian and Lagrangian formulations. In ALE formulation, the material flow is followed and Lagrangian step is used to solve displacement problems, while the mesh is repositioned and Eulerian step is used to solve velocity problems. Eulerian approach is used for modeling the tool tip area where cutting process occurs. Hence, without using remeshing, severe element distortion is avoided. Lagrangian approach is used for the unconstrained material flow at free boundaries. Method involved in the design of a cutter includes:

1. Creation of cross-sectional profile of the tool and helix generation
 - Flute creation using slot operation
 - Creation of back surface of the tool
 - Cutting edge generation
2. Parameters involved in generating the cross sectional profiles are:
 - Rake angle of the tool
 - Relief angle of the tool
 - Tool diameter
3. Parameters involved in modeling the helix are:
 - Height of the tool
 - Diameter of the tool
 - Pitch of the helix

The three dimensional CATIA model of milling cutter was produced by performing Ansys work bench 14.0.

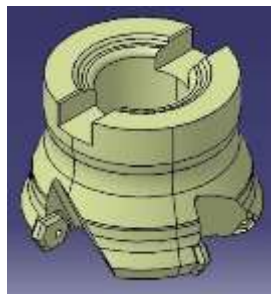


Fig. 7 CATIA model of milling cutter with inserts

Material Description

Cemented Carbide

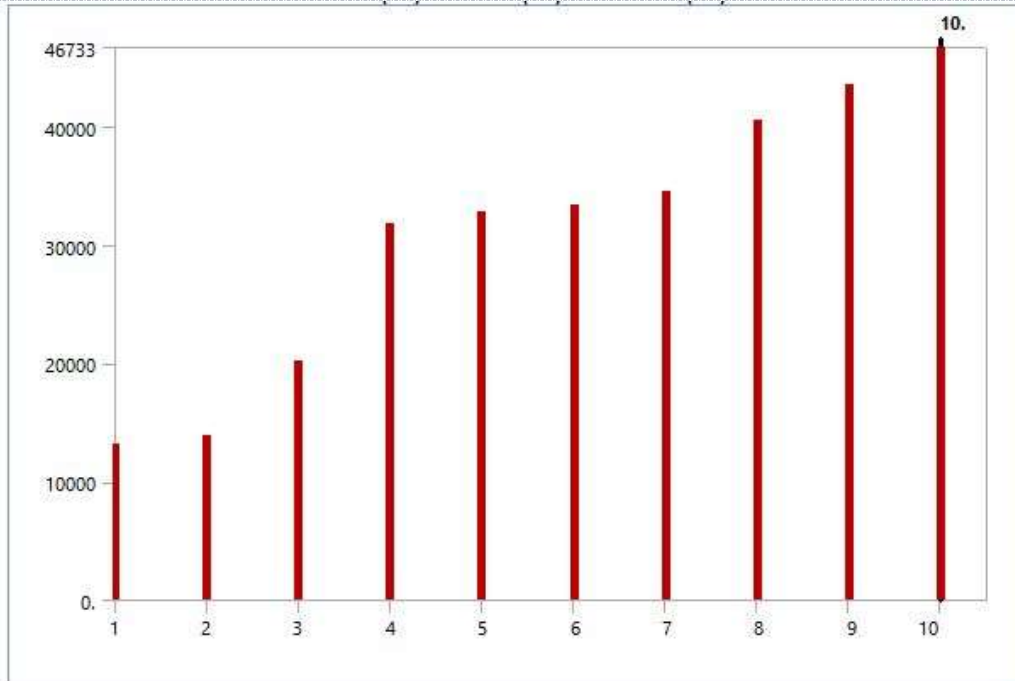
| | |
|---------|--------------------------------|
| Density | 1.525e-005 kg mm ⁻³ |
|---------|--------------------------------|

Cemented Carbide > Isotropic Elasticity

| Young's Modulus MPa | Poisson's Ratio | Bulk Modulus MPa | Shear Modulus MPa |
|---------------------|-----------------|------------------|-------------------|
| 6.e+005 | 0.2 | 3.3333e+005 | 2.5e+005 |

III. RESULTS

After applying the frequency range is 0- 100000 Hz we find that following results:



Model (A4) > Modal (A5) > Solution (A6) > Solution Information

| | |
|---------------------------------|-----------------------------|
| Object Name | <i>Solution Information</i> |
| State | Solved |
| Solution Information | |
| Solution Output | Solver Output |
| Newton-Raphson Residuals | 0 |
| Update Interval | 2.5 s |
| Display Points | All |
| FE Connection Visibility | |
| Activate Visibility | Yes |
| Display | All FE Connectors |
| Draw Connections Attached To | All Nodes |
| Line Color | Connection Type |
| Visible on Results | No |
| Line Thickness | Single |
| Display Type | Lines |

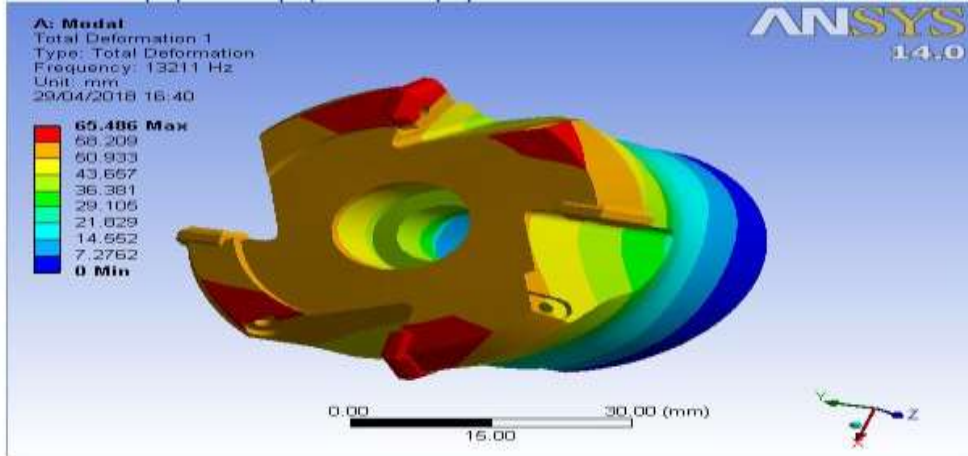
Model (A4) > Modal (A5) > Solution (A6) > Results

| Object Name | <i>Total Deformation</i> | <i>Total Deformation 2</i> | <i>Total Deformation 3</i> | <i>Total Deformation 4</i> | <i>Total Deformation 5</i> |
|-------------------|--------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| State | Solved | | | | |
| Scope | | | | | |
| Scoping Method | Geometry Selection | | | | |
| Geometry | All Bodies | | | | |
| Definition | | | | | |
| Type | Total Deformation | | | | |
| Mode | 1. | 2. | 3. | 4. | 5. |
| Identifier | | | | | |
| Suppressed | No | | | | |

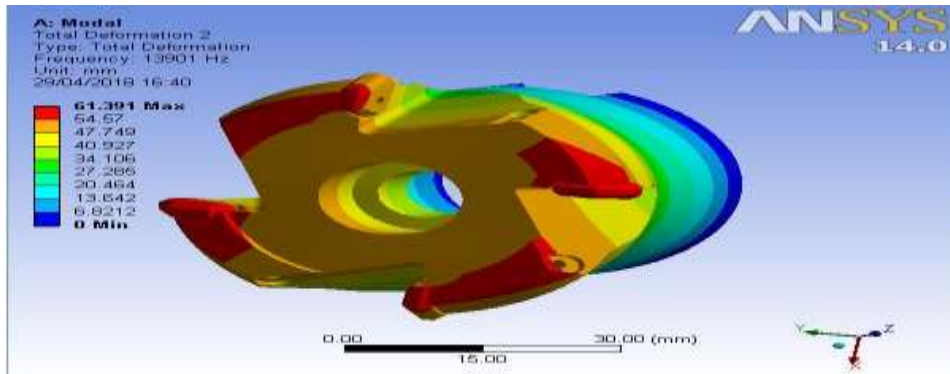
[Bhatia * *et al.*, 7(6): June, 2018]
 ICTM Value: 3.00

| Results | | | | | |
|--------------------|-----------|-----------|-----------|-----------|-----------|
| Minimum | 0. mm | | | | |
| Maximum | 65.486 mm | 61.391 mm | 77.294 mm | 57.673 mm | 97.357 mm |
| Information | | | | | |
| Reported Frequency | 13211 Hz | 13901 Hz | 20218 Hz | 31868 Hz | 32834 Hz |

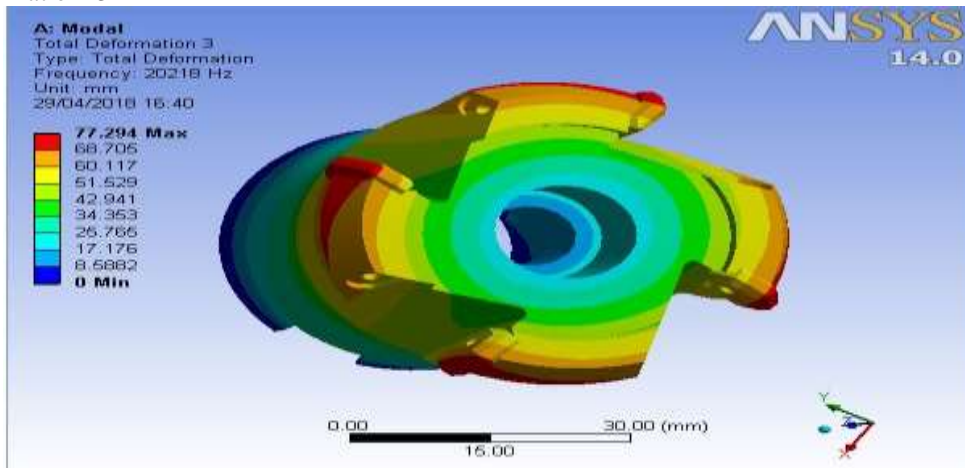
Total Deformation- 1



Total Deformation -2

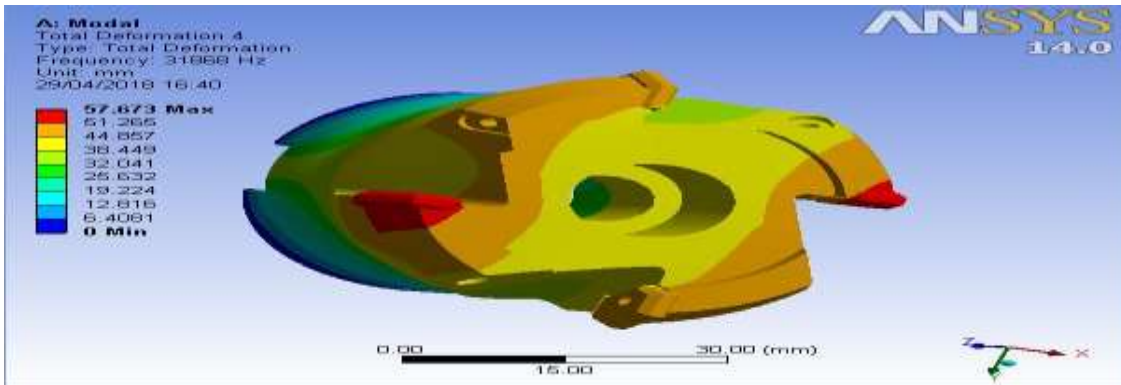


Total deformation- 3

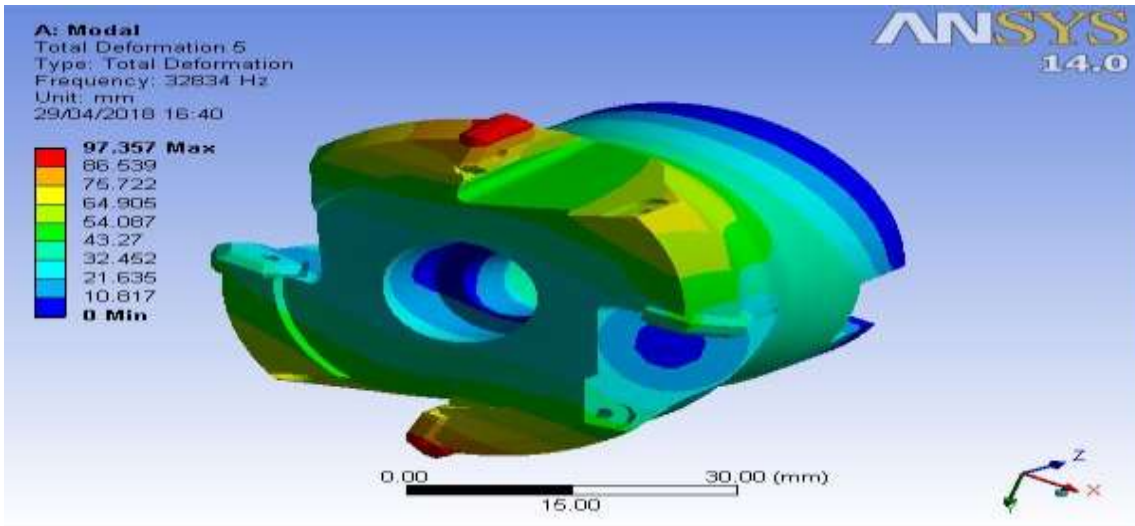


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ICTM Value: 3.00

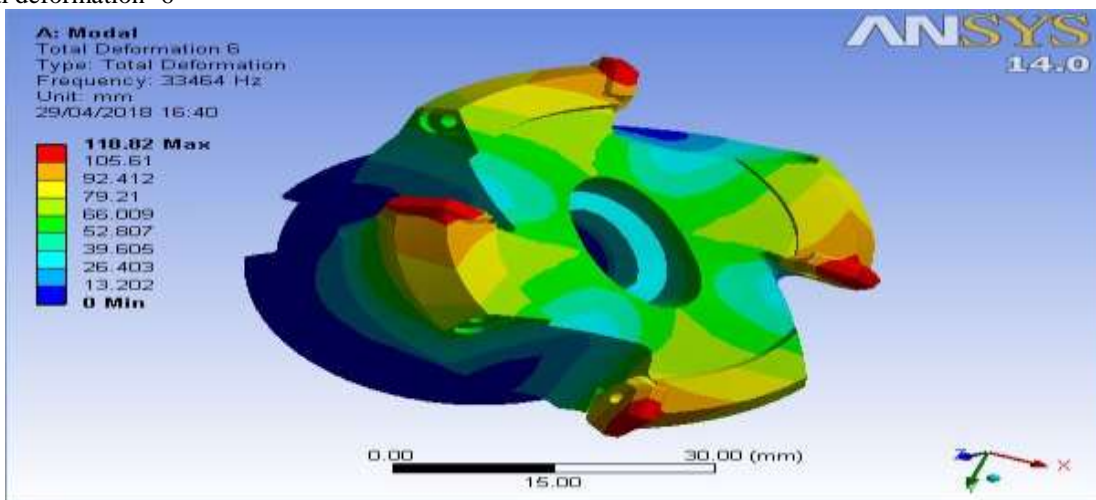
Total deformation -4



Total deformation -5

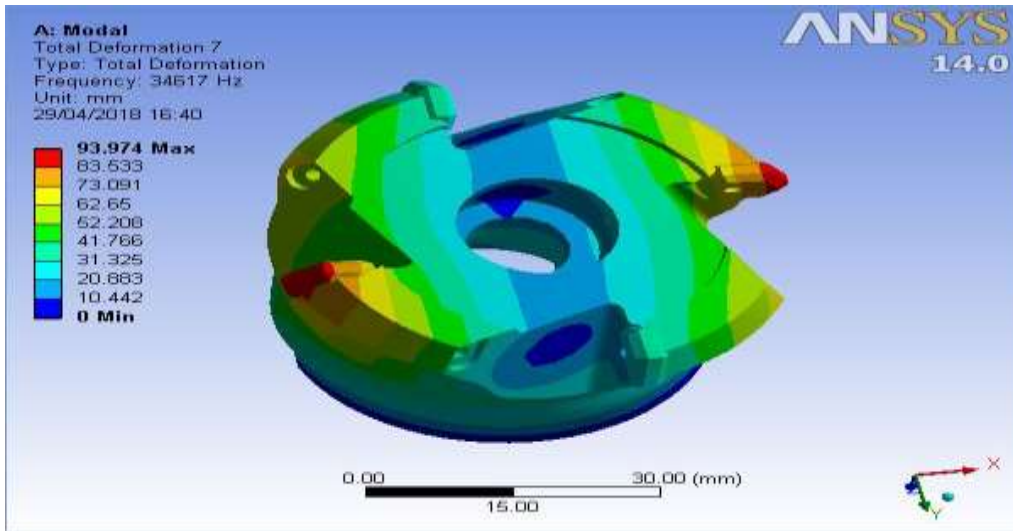


Total deformation- 6

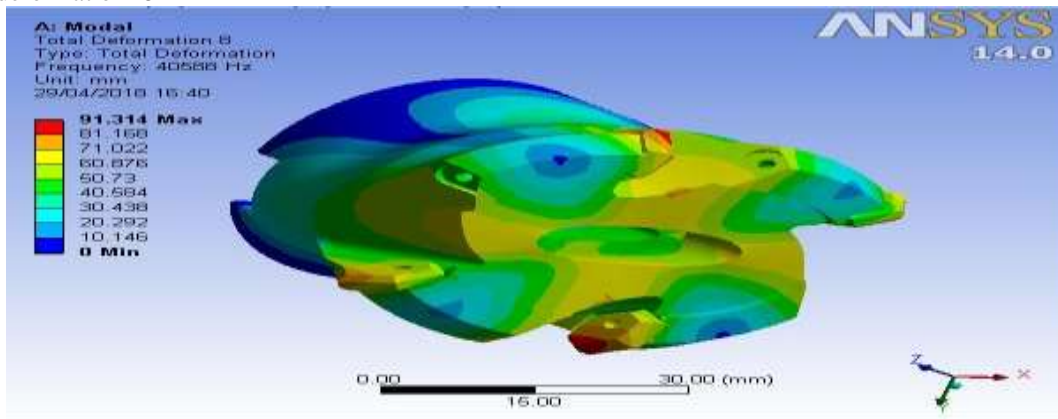


[Bhatia * *et al.*, 7(6): June, 2018]
ICTM Value: 3.00

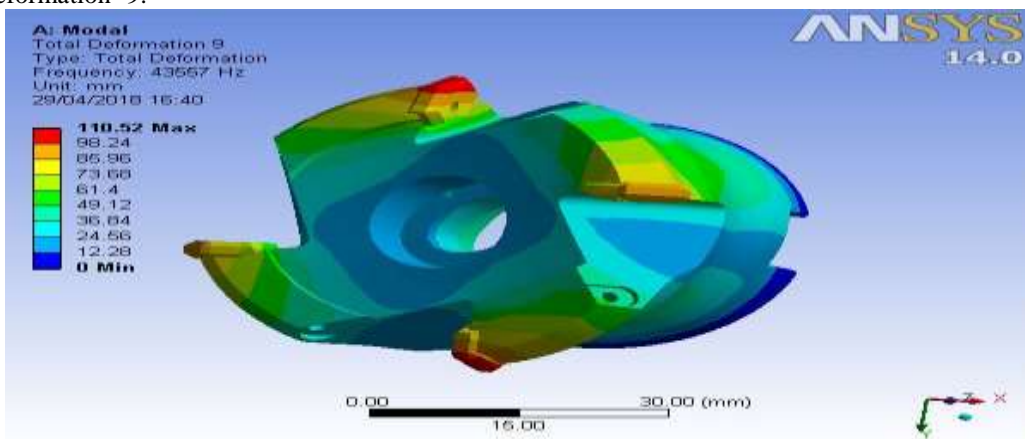
Total deformation -7



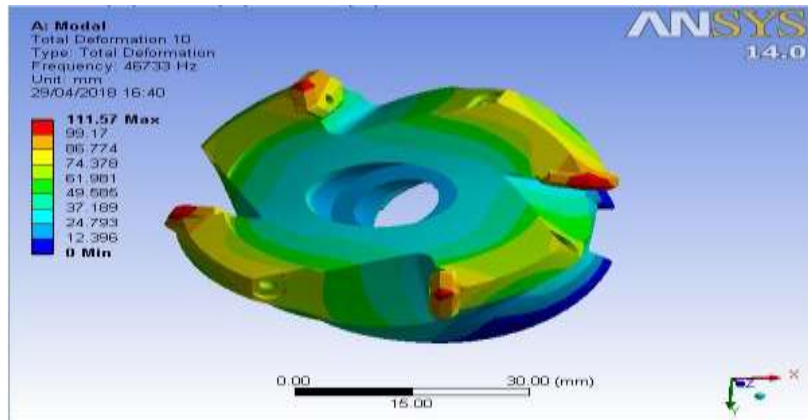
Total deformation -8



Total deformation -9:



Total deformation -10



Result table:

| Mode | Frequency [Hz] |
|------|----------------|
| 1. | 13211 |
| 2. | 13901 |
| 3. | 20218 |
| 4. | 31868 |
| 5. | 32834 |
| 6. | 33464 |
| 7. | 34617 |
| 8. | 40588 |
| 9. | 43557 |
| 10. | 46733 |

IV. CONCLUSION

From the results obtained in ANSYS it can be observed that the deformation for high feed face mill cutter is less than HSS face mill cutter by approximately 34.69%. This is due to the high feed.

- From the results the fail safe condition for the tool has been established by comparing with the practical data.
- At high cutting speed the wear rate is higher and at low cutting speed wear rate is lower on all the tool materials.

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